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Cruise Report: JGOFS Leg 1
International Study of the North Atlantic Bloom

R/V *Atlantis II* Voyage: 119.2
Funchal to Reykjavik
March/April 1989

by

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Woods Hole, Massachusetts 02543

July 1989

Technical Report

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Approved for Distribution:

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David A. Ross, Chairman
Department of Geology & Geophysics

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* Supported by the National Science Foundation OCE-88-14228

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Cruise Report; GOFS Leg 1
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Abstract:

With the support of the National Science Foundation, we have completed the first cruise devoted to the GOFS and JGOFS program for the North Atlantic Bloom studies between March 28 and April 6 on board R/V Atlantis II. The major task of this cruise, to deploy bottom-tethered mooring arrays with time-series sediment traps along with current meters at two critical stations, 34°N and 47°N along 20°W, was accomplished. All 6 sediment traps, 3 on each array, were set at 14-day intervals for 13 periods from April 3 to September 26, 1989. Their opening and closing times were synchronized throughout the period of deployment. The arrays and instruments will be recovered and redeployed in September/October, 1989. Ancillary water column data, such as CTD, fluorometry, pigments, and major nutrient distribution, were also successfully completed (except for transmissometry profiling at the 47°N station) in order to understand the pre-bloom setting at JGOFS 34°N, 47°N, and 60°N stations. At the 47°N station on April 2, the mixed layer depth was 248 m.

1. Objectives of Cruise

The primary objective of this cruise was to deploy 6 time-series sediment traps with 3 current meters at two J-GOFS stations, at 47°N and 34°N along the 20°W transect, inaugurating 12 months of continuous measurement of particle fluxes (Fig. 1). A description of the oceanographic characteristics of the water column before the spring plankton bloom in the North Atlantic takes place was an ancillary objective of this cruise.

2. Accomplishments; Sediment Trap Mooring Array

As proposed, two sediment trap arrays were deployed at positions planned before, and supported by the GOFS Steering Committee. All planned ancillary data were collected at three J-GOFS stations, 60°N, 47°N, and 34°N along 20°W, except for transmissometry profiling at the 47°N station where bad weather prevented deployment of a deep cast within the time allocated to this leg.

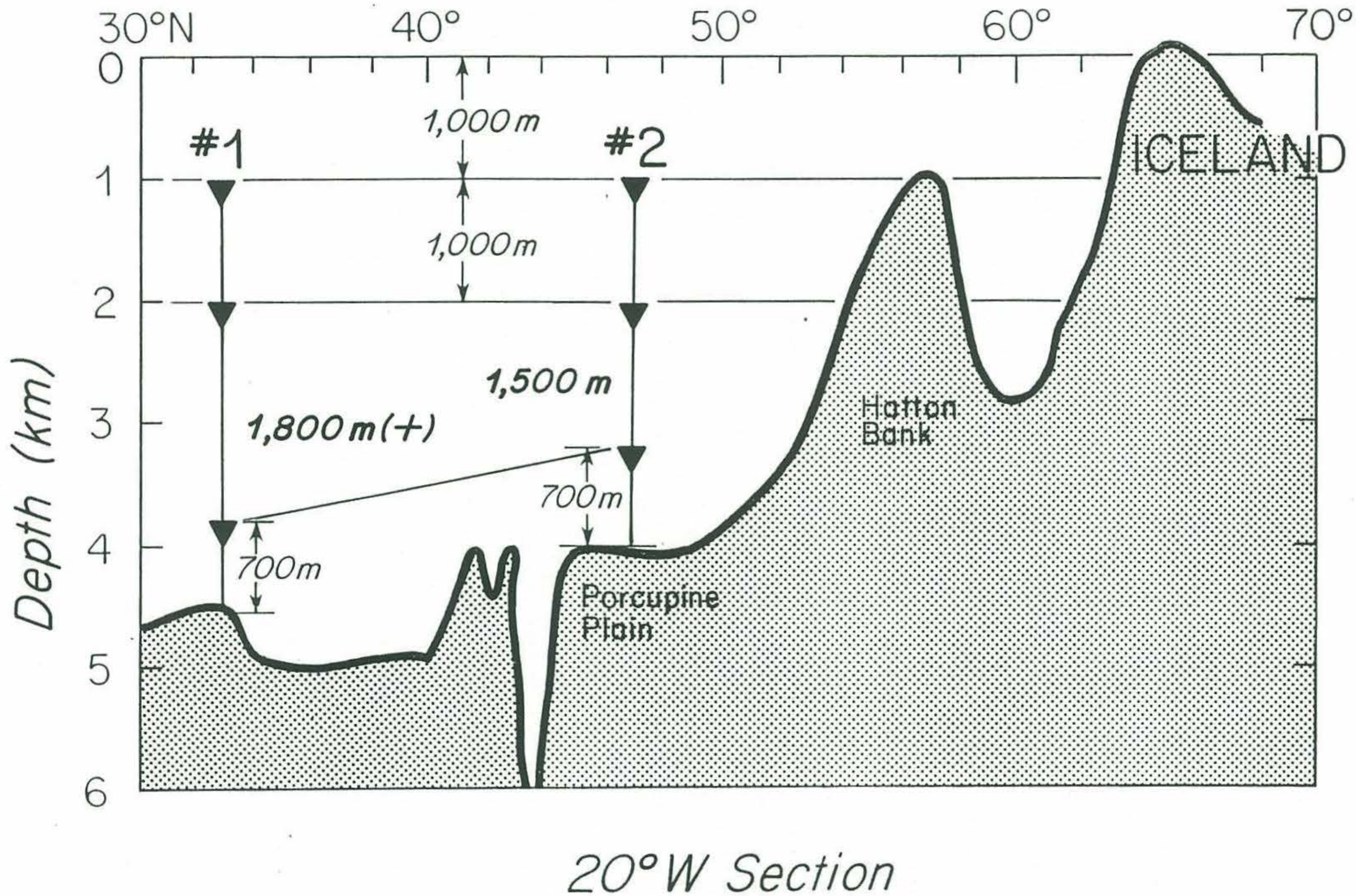


Figure 1. GOFS/JGOFS transect profile approximately along 20°W. Solid triangles indicate approximate depths of sediment traps and current meters. For precise depths of moored instruments, refer Table 4 and 5.

2.1 Time-series sediment trap mooring arrays.

Summary of deployment

Mooring ID: GOFS 3401 (or PARFLUX 1989-1)

Location: 33°49.3N, 21°00.5W
Height of mooring: 4,237.0 m
Depth of summit: 1,024.0 m
Water depth: 5,261.0 m (uncorrected)
Date of deployment: 29 March 1989 (21:52 GMT)
Sediment trap identification numbers and depths:
3401-01: 1,071.5 m below surface (at aperture surface), 4,189.5 m above bottom, serial #535
3401-02: 2,064.0 m below surface, 3,194 m above bottom, serial #534
3401-03: 4,565.5 m below surface, 697.0 m above bottom, serial #538

Mooring ID: GOFS 4701 (or PARFLUX 1989-2)

Location: 47°42.9N, 20°52.5W
Height of mooring: 3,446.0 m
Depth of summit: 1,024.0 m
Water depth: 4,418.0 m (uncorrected)
Date of deployment: 3 April 1989 (00:15 GMT)
Sediment trap identification numbers and depths:
4701-01: 1,018.0 m below surface (at aperture surface), 3,400.0 m above bottom, serial #539. Current meter, serial #2752BF, deployed 2 m below trap.
4701-02: 2,018.0 m below surface, 2,398.5 m above bottom, serial #537. Current meter, serial #2805BF, deployed 2 m below trap.
4701-03: 3,718.0 m below surface, 700.0 m above bottom, serial #536. Current meter, serial #2814BF, deployed 2 m below trap.

Both mooring arrays were deployed in international waters. JGOFS membership countries have agreed to deploy 3 arrays, one each contributed by the United Kingdom, the Federal Republic of Germany, and the Netherlands, approximately 100 Km apart forming a mesoscale array by the end of 1989 in the vicinity of 47°N, 20°W.

2.2 Schedules of moored instruments (Table 1).

All time-series sediment traps deployed during this cruise were PARFLUX Mark 7G-13 with $0.5m^2$ aperture and computer controlled sampling sequence for 13 events (Table 2)(a successor of the Mark 6-13 trap, Honjo and Doherty, 1988) beginning at noon, April 3 (traps open) to September 26, 1989, for time fractionations of 14 days without interruption. The first period was shortened to 4 days in order to synchronize the deployment periods with Dr. John Martin's floating array experiment during Periods 7, 8, and 9. The open-close schedule was the same on all of the 6 time-series sediment traps which were deployed at 3401 and 4701 stations. The rationale for using an open/close schedule of 14 days and trap depths chosen was given in the proposal submitted to the National Science Foundation in March, 1988 (OCE-88-14228). The open/close schedule of the traps, which applies to all 6 traps (Table 1), is as follows:

Table 1. Trap open/close schedule

	Date	Julian Day	Time	Open Duration (day/hour)
Event 01 of 14	04/03/89	093	12:00:00 open only	
Event 02 of 14	04/08/89	098	12:00:00 open/close	5.00*
Event 03 of 14	04/22/89	112	12:00:00 open/close	14.00
Event 04 of 14	05/06/89	126	12:00:00 open/close	14.00
Event 05 of 14	05/20/89	140	12:00:00 open/close	14.00
Event 06 of 14	06/06/89	157	12:00:00 open/close	17.00*
Event 07 of 14	06/20/89	171	12:00:00 open/close	14.00
Event 08 of 14	07/04/89	185	12:00:00 open/close	14.00
Event 09 of 14	07/18/89	199	12:00:00 open/close	14.00
Event 10 of 14	08/01/89	213	12:00:00 open/close	14.00
Event 11 of 14	08/15/89	227	12:00:00 open/close	14.00
Event 12 of 14	08/29/89	241	12:00:00 open/close	14.00
Event 13 of 14	09/12/89	255	12:00:00 open/close	14.00
Event 14 of 14	09/26/89	269	12:00:00 close only	14.00

* Note deviation from the standard interval (14.00 days).

The specifications of the Mark 7G-13 sediment trap, developed for GOFS, are summarized in Table 2.

The sampling rate of the current meters is set to every one-half hour. Current vectors and temperatures will be measured throughout the operating period of the sediment traps.

Table 2. Mark &G-13 Time-series Sediment Trap Specification Summary

General Configuration: Acute cone-shaped funnel concentrator with baffle, electronically controlled sequential samplers which are sealed against ambient water during the storage mode, build inside of titanium structural frame and moored "in-line" mode

Configuration	
height	152 cm
diameter	91 cm
app. vertical surface area	0.66 m^2
Weight (without bridals)	
in air	75 kg
in water	55 kg
Aperture/Funnel	
aperture diameter	80 cm
aperture area	0.5 m^2
appr. no. of baffle cells	368
baffle cell diameter	25 mm
aspect ratio of a cell	2.5
included cone-angle	42°
bottom diameter (ID)	3.0cm
Rotary sampler assembly	
no. of sampling bottles	13
standard bottle volume	250 ml
rotary disk diameter	40 cm
type of driving moter	Electronic Stepping moter
drive train	direct gear train
drive torque at the 2nd spur	30 kg/cm
time to shift a bottle	80 sec.
Timer/Logger	Hardware: McLane 1TC 1.0 Software : ITC Operation Prog.
Battery	
primary battery	McLane A21-1000
memory back-up	9 V transistor battery
Frame	
tube diameter	3.8 cm
ring diameter	91 cm
ring dimension (cm)	5x5x1 angle
bridles	3 and 3
Operational Depth	Mk 7G-13 : 5,500 m Mk 7GD-13 : any ocean depth
Operation Duration	
min. deployment period	a few minute times 13
max. continuous deployment	about 2 years in deep ocean

2.3 Preparation of sediment traps.

We followed the standard PARFLUX procedure in preparing for deployment of sediment traps: first, to cast for water from each depth where the traps are scheduled to be moored; second, to mix these water samples with preservatives; and last to fill the sampler cups of the traps with the mixture for the appropriate depths. Because of adverse weather, we were not able to complete deep casts at the 47°N station; thus, we used deep water collected at 1,000, 3,492, and 4,092 m (nominal) from 33°51'4N, 21°05'5W, to which was added a preservative and a pH buffer and kept dark-refrigerated for later use.

Table 3.

Sample	Water source	Traps at 3401	Traps at 4701
WCS34-03	1,000 m	1,071.0 mbs	1,018.0 mbs
WCS34-02	3,492	2,064.0	2,018.0
WCS34-01	4,092	4,565.5	3,718.0

We added formalin to 3%, added 0.1% Borax as a buffer, filled each sampler cup to the top, and sealed each cup by rotating the sampler plate of the sediment trap. They will remain sealed until opened to seawater at the designated time.

2.4 Mooring array

The mooring design is based on the "PARFLUX Sediment Trap Mooring Dynamics Package," which: 1) maintains the sediment traps along the mooring line to be as stable as possible, and 2) keeps the performance of the array, including tilting of traps, as predictable and efficiently deployed and recovered from an ordinary research vessel even in heavy seas. The two arrays deployed deviated slightly from the "Standard GOFS bottom-tethered mooring" proposed in March, 1988 (Fig. 2). Tables 4 and 5 show detailed lists of the 34°N and 60°N arrays including the upward tension scheme at terminations (column 6) and depths above the bottom (mab, column 7) and below the surface (mbs, column 8). All depths given in these tables are not (acoustically) corrected. The summary of data on predicted performance of those two moorings by PARFLUX engineering numerical models is shown in Table 6.

The water filled sampler cups were then analyzed with regard to nutrients according to Strickland and Parsons (1972) and amended if required per Grasshoff et al., 1983. The values will be compared later with supernatant in each sampler cup to detect the leaching of nutrients from the settled particles in it. The analytical results were with the additives mentioned above (Table 7).

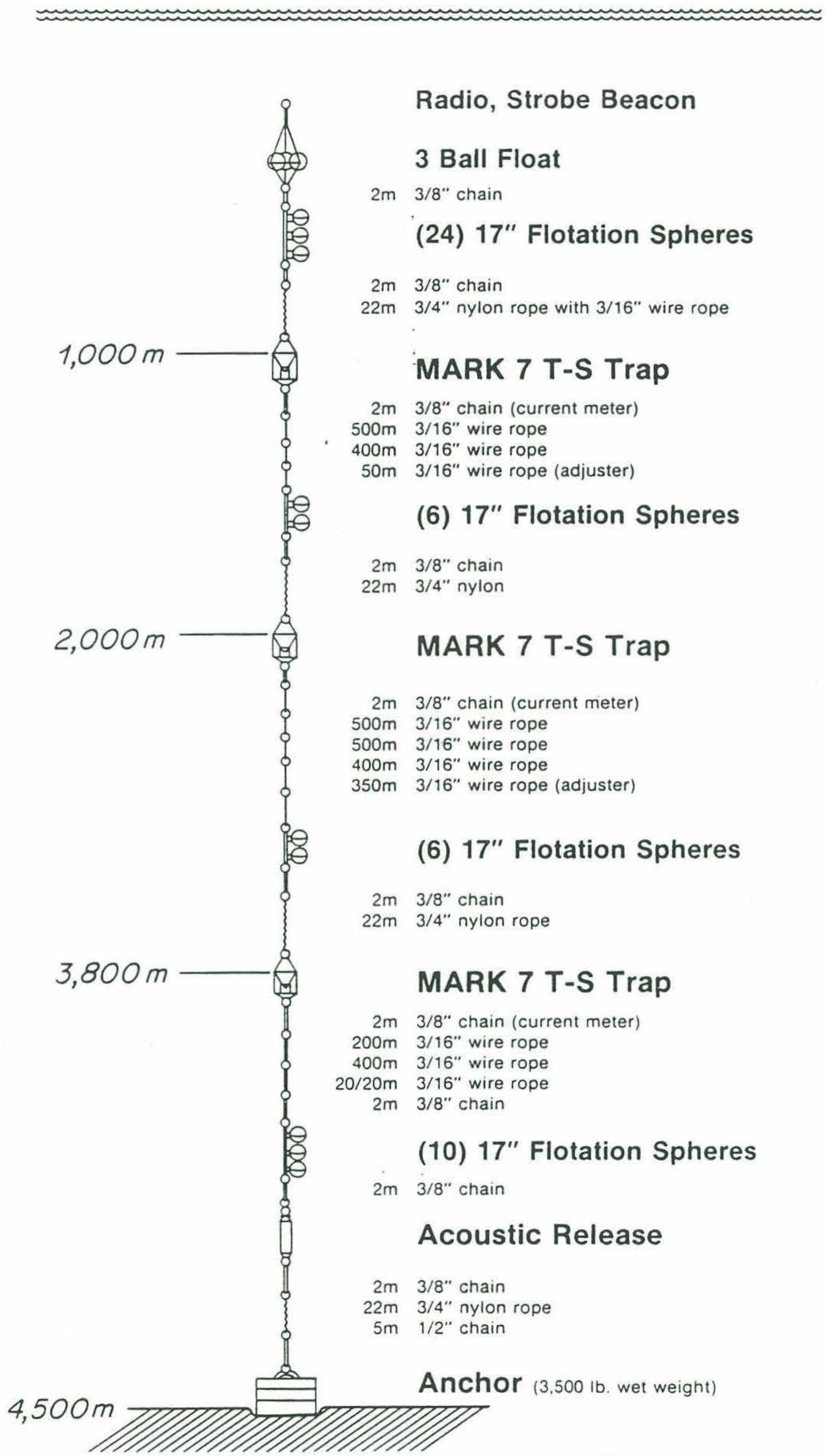

Radio, Strobe Beacon
3 Ball Float
2m 3/8" chain
(24) 17" Flotation Spheres
2m 3/8" chain
22m 3/4" nylon rope with 3/16" wire rope
1,000 m
MARK 7 T-S Trap
2m 3/8" chain (current meter)
500m 3/16" wire rope
400m 3/16" wire rope
50m 3/16" wire rope (adjuster)
(6) 17" Flotation Spheres
2m 3/8" chain
22m 3/4" nylon
2,000 m
MARK 7 T-S Trap
2m 3/8" chain (current meter)
500m 3/16" wire rope
500m 3/16" wire rope
400m 3/16" wire rope
350m 3/16" wire rope (adjuster)
(6) 17" Flotation Spheres
2m 3/8" chain
22m 3/4" nylon rope
3,800 m
MARK 7 T-S Trap
2m 3/8" chain (current meter)
200m 3/16" wire rope
400m 3/16" wire rope
20/20m 3/16" wire rope
2m 3/8" chain
(10) 17" Flotation Spheres
2m 3/8" chain
Acoustic Release
2m 3/8" chain
22m 3/4" nylon rope
5m 1/2" chain
Anchor (3,500 lb. wet weight)
4,500m

Figure 2.

Table 4, 34 dgr. Station

Mooring I.D. = GOFS 3401 (33.49.3N, 21.00.5W) Water Depth = 5261.00

Specifications Description	*Item Weight (lb/m,ea#*	*Item Quantity*	*Item Length Item*	*Item Weight Item*	*Mooring Length (m)*	*Mooring Weight(lb) (lb)*	*Above Bottom mab*	*Below Surface mbs*
FLOAT with 3BALLS,RA	-151.00	1.00	1.00	-151.00	1.00	-151.00	4237.00	1024.00
chain, 3/8"	4.49	1.00	2.00	8.98	3.00	-142.02	4236.00	1025.00
GLASS BALLS 17"on 1m	-51.00	20.00	20.00	-1020.00	23.00	-1162.02	4234.00	1027.00
nylon rope,3/4"	0.05	1.00	20.00	1.04	43.00	-1160.98	4214.00	1047.00
chain, 3/8"	4.49	1.00	2.00	8.98	45.00	-1152.00	4194.00	1067.00
bridle,(1m wire rope	9.06	1.00	1.00	9.06	46.00	-1142.94	4192.00	1069.00
SEDIMENT TRAP MK7	121.00	1.00	1.52	121.00	47.52	-1021.94	4191.00	1070.00
bridle,(1m wire rope	9.06	1.00	1.00	9.06	48.52	-1012.88	4189.48	1071.52
chain, 3/8"	4.49	1.00	2.00	8.98	50.52	-1003.90	4188.48	1072.52
wire rope.3/16"	0.15	1.00	500.00	75.00	550.52	-928.90	4186.48	1074.52
wire rope.3/16"	0.15	1.00	400.00	60.00	950.52	-868.90	3686.48	1574.52
wire rope.3/16"	0.15	1.00	61.48	9.22	1012.00	-859.68	3286.48	1974.52
GLASS BALLS 17"on 1m	-51.00	8.00	8.00	-408.00	1020.00	-1267.68	3225.00	2036.00
nylon rope,3/4"	0.05	1.00	20.00	1.04	1040.00	-1266.64	3217.00	2044.00
chain, 3/8"	4.49	1.00	2.00	8.98	1042.00	-1257.66	3197.00	2064.00
bridle,(1m wire rope	9.06	1.00	1.00	9.06	1043.00	-1248.60	3195.00	2066.00
SEDIMENT TRAP MK7	121.00	1.00	1.52	121.00	1044.52	-1127.60	3194.00	2067.00
bridle,(1m wire rope	9.06	1.00	1.00	9.06	1045.52	-1118.54	3192.48	2068.52
chain, 3/8"	4.49	1.00	2.00	8.98	1047.52	-1109.56	3191.48	2069.52
wire rope.3/16"	0.15	1.00	500.00	75.00	1547.52	-1034.56	3189.48	2071.52
wire rope.3/16"	0.15	1.00	500.00	75.00	2047.52	-959.56	2689.48	2571.52
wire rope.3/16"	0.15	1.00	500.00	75.00	2547.52	-884.56	2189.48	3071.52
wire rope.3/16"	0.15	1.00	500.00	75.00	3047.52	-809.56	1689.48	3571.52
wire rope.3/16"	0.15	1.00	400.00	60.00	3447.52	-749.56	1189.48	4071.52
wire rope.3/16"	0.15	1.00	61.48	9.22	3509.00	-740.34	789.48	4471.52
GLASS BALLS 17"on 1m	-51.00	8.00	8.00	-408.00	3517.00	-1148.34	728.00	4533.00
nylon rope,3/4"	0.05	1.00	20.00	1.04	3537.00	-1147.30	720.00	4541.00
chain, 3/8"	4.49	1.00	2.00	8.98	3539.00	-1138.32	700.00	4561.00
bridle,(1m wire rope	9.06	1.00	1.00	9.06	3540.00	-1129.26	698.00	4563.00
SEDIMENT TRAP MK7	121.00	1.00	1.52	121.00	3541.52	-1008.26	697.00	4564.00
bridle,(1m wire rope	9.06	1.00	1.00	9.06	3542.52	-999.20	695.48	4565.52
chain, 3/8"	4.49	1.00	2.00	8.98	3544.52	-990.22	694.48	4566.52
wire rope.3/16"	0.15	1.00	500.00	75.00	4044.52	-915.22	692.48	4568.52
wire rope.3/16"	0.15	1.00	100.00	15.00	4144.52	-900.22	192.48	5068.52
wire rope.3/16"	0.15	1.00	47.48	7.12	4192.00	-893.09	92.48	5168.52
GLASS BALLS 17"on 1m	-51.00	12.00	12.00	-612.00	4204.00	-1505.09	45.00	5216.00
chain, 3/8"	4.49	1.00	2.00	8.98	4206.00	-1496.11	33.00	5228.00
ACOUSTIC RELEASE	55.00	1.00	1.00	55.00	4207.00	-1441.11	31.00	5230.00
chain, 3/8"	4.49	1.00	5.00	22.45	4212.00	-1418.66	30.00	5231.00
nylon rope,3/4"	0.05	1.00	20.00	1.04	4232.00	-1417.62	25.00	5236.00
chain, 3/8"	4.49	1.00	5.00	22.45	4237.00	-1395.17	5.00	5256.00
ANCHOR	0.89	3200.00	0.00	2848.00	4237.00	1452.83	0.00	5261.00

Table 5, 47 dgr. Station

Mooring I.D. = GOFS 4701 (47.42.87N, 20.52.49W)   Water Depth = 4418.00

Specifications Description	Weight (lb/m,ea#	Item Quantity	Item Length Item	Item Weight Item	Mooring Length (m)	Mooring Weight(lb) (lb)	Above Bottom mab	Below Surface mbs
FLOAT with 3BALLS,RA	-151.00	1.00	1.00	-151.00	1.00	-151.00	3446.00	972.00
chain, 3/8"	4.49	1.00	2.00	8.98	3.00	-142.02	3445.00	973.00
GLASS BALLS 17"on 1m	-51.00	20.00	20.00	-1020.00	23.00	-1162.02	3443.00	975.00
nylon rope,3/4"	0.05	1.00	20.00	1.04	43.00	-1160.98	3423.00	995.00
chain, 3/8"	4.49	1.00	2.00	8.98	45.00	-1152.00	3403.00	1015.00
bridle,(1m wire rope	9.06	1.00	1.00	9.06	46.00	-1142.94	3401.00	1017.00
SEDIMENT TRAP MK7	121.00	1.00	1.52	121.00	47.52	-1021.94	3400.00	1018.00
bridle,(1m wire rope	9.06	1.00	1.00	9.06	48.52	-1012.88	3398.48	1019.52
chain, 3/8"	4.49	1.00	2.00	8.98	50.52	-1003.90	3397.48	1020.52
CURRENT METER	10.00	1.00	1.00	10.00	51.52	-993.90	3395.48	1022.52
chain, 3/8"	4.49	1.00	2.00	8.98	53.52	-984.92	3394.48	1023.52
wire rope.3/16"	0.15	1.00	500.00	75.00	553.52	-909.92	3392.48	1025.52
wire rope.3/16"	0.15	1.00	400.00	60.00	953.52	-849.92	2892.48	1525.52
wire rope.3/16"	0.15	1.00	61.48	9.22	1015.00	-840.70	2492.48	1925.52
GLASS BALLS 17"on 1m	-51.00	8.00	8.00	-408.00	1023.00	-1248.70	2431.00	1987.00
nylon rope,3/4"	0.05	1.00	20.00	1.04	1043.00	-1247.66	2423.00	1995.00
chain, 3/8"	4.49	1.00	2.00	8.98	1045.00	-1238.68	2403.00	2015.00
bridle,(1m wire rope	9.06	1.00	1.00	9.06	1046.00	-1229.62	2401.00	2017.00
SEDIMENT TRAP MK7	121.00	1.00	1.52	121.00	1047.52	-1108.62	2400.00	2018.00
bridle,(1m wire rope	9.06	1.00	1.00	9.06	1048.52	-1099.56	2398.48	2019.52
chain, 3/8"	4.49	1.00	2.00	8.98	1050.52	-1090.58	2397.48	2020.52
CURRENT METER	10.00	1.00	1.00	10.00	1051.52	-1080.58	2395.48	2022.52
chain, 3/8"	4.49	1.00	2.00	8.98	1053.52	-1071.60	2394.48	2023.52
wire rope.3/16"	0.15	1.00	500.00	75.00	1553.52	-996.60	2392.48	2025.52
wire rope.3/16"	0.15	1.00	500.00	75.00	2053.52	-921.60	1892.48	2525.52
wire rope.3/16"	0.15	1.00	500.00	75.00	2553.52	-846.60	1392.48	3025.52
wire rope.3/16"	0.15	1.00	100.00	15.00	2653.52	-831.60	892.48	3525.52
wire rope.3/16"	0.15	1.00	61.48	9.22	2715.00	-822.38	792.48	3625.52
GLASS BALLS 17"on 1m	-51.00	8.00	8.00	-408.00	2723.00	-1230.38	731.00	3687.00
nylon rope,3/4"	0.05	1.00	20.00	1.04	2743.00	-1229.34	723.00	3695.00
chain, 3/8"	4.49	1.00	2.00	8.98	2745.00	-1220.36	703.00	3715.00
bridle,(1m wire rope	9.06	1.00	1.00	9.06	2746.00	-1211.30	701.00	3717.00
SEDIMENT TRAP MK7	121.00	1.00	1.52	121.00	2747.52	-1090.30	700.00	3718.00
bridle,(1m wire rope	9.06	1.00	1.00	9.06	2748.52	-1081.24	698.48	3719.52
chain, 3/8"	4.49	1.00	2.00	8.98	2750.52	-1072.26	697.48	3720.52
CURRENT METER	10.00	1.00	1.00	10.00	2751.52	-1062.26	695.48	3722.52
chain, 3/8"	4.49	1.00	2.00	8.98	2753.52	-1053.28	694.48	3723.52
wire rope.3/16"	0.15	1.00	500.00	75.00	3253.52	-978.28	692.48	3725.52
wire rope.3/16"	0.15	1.00	100.00	15.00	3353.52	-963.28	192.48	4225.52
wire rope.3/16"	0.15	1.00	47.48	7.12	3401.00	-956.15	92.48	4325.52
GLASS BALLS 17"on 1m	-51.00	12.00	12.00	-612.00	3413.00	-1568.15	45.00	4373.00
chain, 3/8"	4.49	1.00	2.00	8.98	3415.00	-1559.17	33.00	4385.00
ACOUSTIC RELEASE	55.00	1.00	1.00	55.00	3416.00	-1504.17	31.00	4387.00
chain, 3/8"	4.49	1.00	5.00	22.45	3421.00	-1481.72	30.00	4388.00
nylon rope,3/4"	0.05	1.00	20.00	1.04	3441.00	-1480.68	25.00	4393.00
chain, 3/8"	4.49	1.00	5.00	22.45	3446.00	-1458.23	5.00	4413.00
ANCHOR	0.89	3200.00	0.00	2848.00	3446.00	1389.77	0.00	4418.00

Table 6. A summary of the engineering model of the GOFS mooring array behavior under various rates of advection.

Parameter	Zero Current	10 cm/s	25cm/s	50 cm/s
Depth @ 1000m	1000m	1001.5	1058.1	1637.5
Δz @ 1000m	0	0.6	58.1	637.5
Inclination @ 1000m	0	0.8°	4.7°	18.7°
Depth @ 2000m	2000m	2001.4	2051.9	2551.9
Δz @ 2000m	0	1.2	51.9	551.9
Inclination @ 2000m	0	1.2°	7.8°	28.3°
Depth @ 3800m	3800m	3800.7	3828.2	3995.2
Δz @ 3800m	0	0.6	28.2	274.1
Inclination @ 3800m	0	0.8°	12.0°	39.6°
Wire: min. safety factor	2.4	2.4	2.4	2.4
Nylon: min safety factor	7.0	7.0	7.0	6.9
Chain: min safety factor	5.7	5.7	5.8	5.8

GOFS 3401, 4701, 6001 Stations, April 20, 1989

Location	Cast #	Depth (m)	PO4	NO3+NO2	NO2	NO3
60°N Station						
6-Apr-89						
	22.0 c-5	0	0.89	14.7	0.1	14.6
	21.0 c-5	10	0.89	14.7	0.1	14.7
	20.0 c-5	20	0.88	15.0	0.1	14.9
	19.0 c-5	50	0.89	14.9	0.1	14.9
	18.0 c-5	100	0.92	15.4	0.1	15.3
	17.0 c-5	1000	1.17	19.6	0.0	19.5
47°N Station						
3-Apr-89						
	16.0 c-4	0	0.64	9.5	0.1	9.4
	15.0 c-4	10	0.56	9.4	0.1	9.3
	14.0 c-4	20	0.56	9.4	0.1	9.3
	13.0 c-4	50	0.56	9.6	0.1	9.5
	12.0 c-4	100	0.58	9.8	0.1	9.6
	11.0 c-4	1000	1.22	20.7	0.0	20.7
34°N Station						
29-Mar-89						
	9.0 c-2	0	0.01	0.4	0.1	0.3
	8.0 c-2	10	0.05	0.3	0.0	0.2
	7.0 c-2	20	0.05	0.3	0.0	0.3
	6.0 c-2	50	0.05	0.5	0.1	0.4
	5.0 c-2	100	0.09	0.9	0.1	0.8
	4.0 c-2	400	0.63	11.3	0.0	11.3
	3.0 c-1	1000	0.78	14.1	0.0	14.0
	2.0 c-1	3492	1.47	23.3	0.0	23.2
	1.0 c-1	4092	1.42	23.5	0.0	23.4
	10.0 c-3	5185	1.51	23.7	0.0	23.7
Sediment Trap Cup water						
Water from Cast #1						
3% formalin, .1% borax						
	25.0 cup H	1000	0.86	13.0	0.0	13.0
	24.0 cup H	3492	1.51	21.7	0.0	21.7
	23.0 cup H	4092	1.51	21.7	0.0	21.7

		Nutrient concentration in umole/liter					
Station	Depth (m)	NH3	N-TOTIN	N-TOT	N-TOTOR	P-TOT	P-TOTOR
60	0	0.0	14.7	17.4	2.8	1.6	0.7
60	10	0.0	14.7	19.6	4.9	1.0	0.1
60	20	0.1	15.1	19.9	4.9	1.0	0.1
60	50	0.0	14.9	17.5	2.5	1.1	0.2
60	100	0.0	15.4	22.2	6.9	1.4	0.4
60	1000	0.1	19.7	30.1	10.5	1.7	0.6
47	0	0.4	9.9	26.2	16.4	2.7	2.0
47	10	0.1	9.5	9.5	0.0	0.6	0.0
47	20	0.1	9.5	19.3	9.8	1.0	0.4
47	50	0.1	9.7	12.6	3.0	0.9	0.3
47	100	0.0	9.8	19.9	10.1	1.1	0.5
47	1000	0.0	20.7	22.2	1.5	1.2	0.0
34	0	2.1	2.5	7.9	5.5	0.5	0.5
34	10	0.0	0.3	6.3	6.0	0.5	0.4
34	20	0.0	0.3	2.7	2.4	0.2	0.2
34	50	0.0	0.5	8.1	7.7	0.5	0.4
34	100	0.0	0.9	6.8	5.9	0.5	0.4
34	400	0.0	11.3	23.1	11.8	0.9	0.3
34	1000	0.0	14.1	25.9	11.8	1.0	0.3
34	3492	0.0	23.3	28.5	5.3	1.7	0.2
34	4092	0.0	23.5	29.7	6.2	1.5	0.1
34	5185	0.0	23.7	26.1	2.4	1.5	0.0
34	1000	0.3	13.4	4.6		1.1	0.3
34	3492	0.3	22.0	13.1		1.7	0.2
34	4092	0.3	22.0	13.7		1.9	0.4

Station	Depth (m)	SiO2	Sus.Part. ug/l	Chlor. ug/l	Phaeo. ug/l	Chl.+Phaeo. ug/l
60	0	7.0	35.3	0.11	0.06	0.17
60	10	6.5	31.3			
60	20	6.4	25.1	0.12	0.07	0.19
60	50	6.5	26.9	0.14	0.08	0.22
60	100	6.8	23.7			
60	1000	12.0	15.5			
47	0	3.0	31.9	0.06	0.06	0.12
47	10	2.7	32.5			
47	20	2.8	36.4	0.09	0.08	0.17
47	50	2.7	29.9	0.03	0.05	0.08
47	100	2.7	42.0	0.03	0.05	0.08
47	1000	12.3	27.4	-0.02	0.10	0.08
34	0	0.1	183.3			
34	10	0.2	111.0			
34	20	0.4	114.5	0.35	0.26	0.61
34	50	0.2	89.3	0.26	0.29	0.55
34	100	0.4	103.7			
34	400	3.6	28.7			
34	1000	5.1	57.1			
34	3492	44.0	21.2			
34	4092	49.3	27.6			
34	5185	53.4	37.0			
34	1000	7.2				
34	3492	45.6				
34	4092	51.3				

3. Accomplishments; water column measurements

In order to characterize the pre-bloom water column in the JGOFS North Atlantic Bloom Study area, we lowered a self-contained CTD instrument package with a fluorometer. We cast water samples at 6 to 10 depths to measure major nutrient contents, chlorophyll standing crops, and suspended particles. At mooring station GOFS 4301, we deployed a transmissometer to 15 m above the 5,261 m bottom in search of a nepheloid layer.

Those three hydrostations were:

	Latitude	Longitude	Water Depth	Date
60°N station	60°00.4N	22°15.6W	2,625 m	04/06/89
47°N station	47°42.9N	20°52.5W	4,418 m	04/03/89
34°N station	33°49.3N	21°00.5W	5,215 m	03/29/89

3.1 Conductivity and temperature

We used a Sea-Bird SeaCat unit, 0.01 degrees temperature, 0.01 mS/cm conductivity at an .5 sec. sampling rate to approximately 1,200 m by lowering the ship's hydrowire at 40 m/minute. The sensors were calibrated by SBI, Inc., Bellevue, WA, about 3 weeks prior to deployment. The (electronically filtered) profile is presented as Fig. 3 but CTD data from the 34°N station were not available due to electronic error which occurred onboard after deployment.

The CTD profile from the **47°N station** (Fig. 3) showed a well-defined mixed layer from the surface to about 248 m at 17:00, April 2, 1989. The average temperature and salinity of the mixed layer were 11.6°C and 35.57 ppt, respectively. There seemed to be a reversal of salinity and temperature at the major thermocline at 640 m to 800 m.

The CTD profile from the **60°N station** (Fig. 4) indicated a progressive decay of the upper mixed layer to 210 m observed at 01:30, April 6, 1989. A better defined mixed layer was found to about 400 m.

Figure 3

CTD Profile
47°N Station
April 3, 1989
GOFS, Leg 1

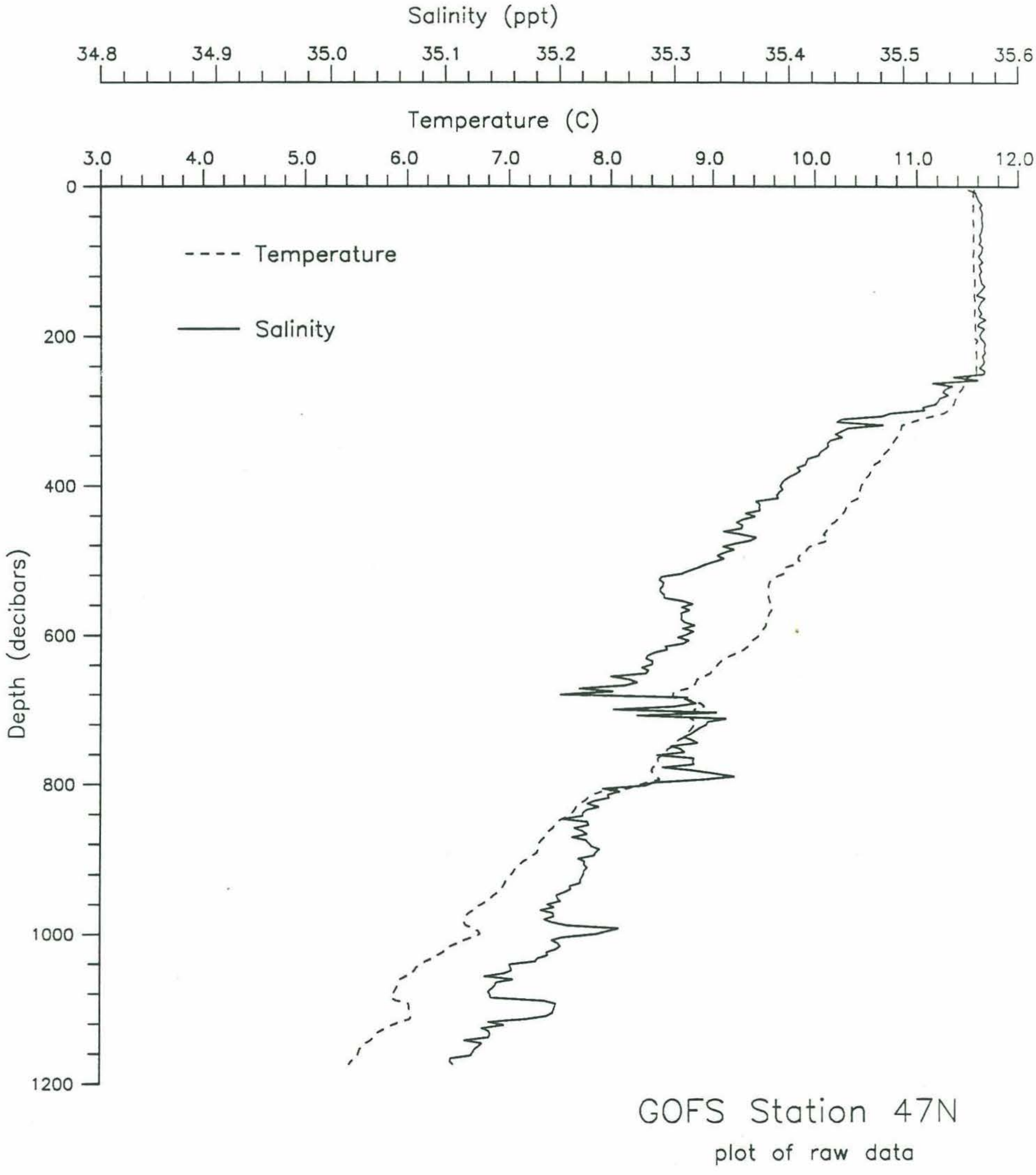
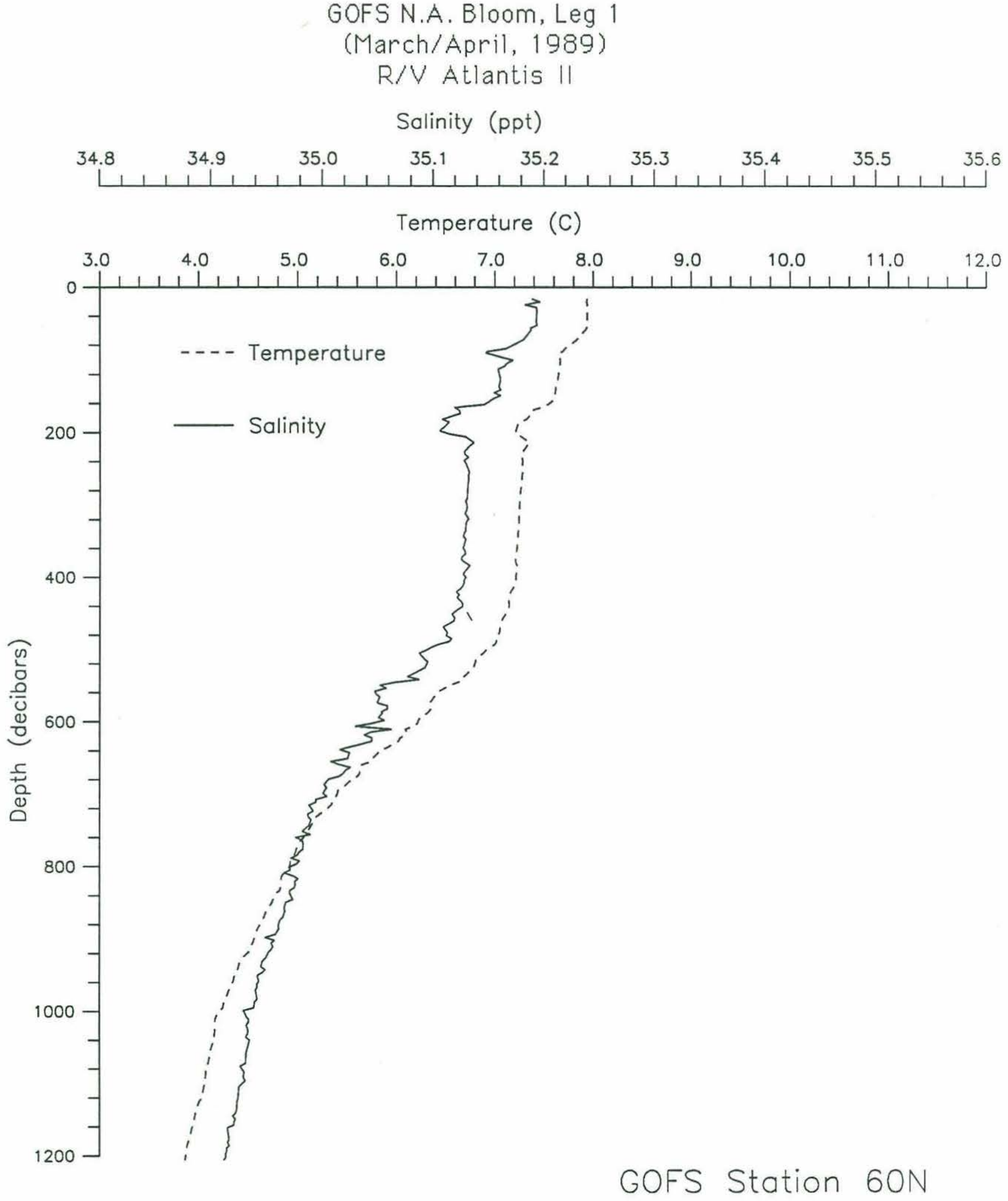


Figure 4

CTD Profile, April 6, 1989



3.2 Fluorometry profile and chlorophyll standing stock

A Sea-Tech fluorometer was lowered in (electronic) synchronization with the CTD unit but its information was recorded in its own solid state electronic data logger. The fluorometer had a standard filter; excitation peaked at 425 nm (100 nm HPBW) and emission peaked at 680 nm (50 nm HPBW). The chlorophyll and pheopigment contents were assessed using a spectroscopic method (10 cm path) according to Strickland and Parsons (1967) in cast water. The chlorophyll *a* contents (Table 7) and Sea-Tech's fluorescence scale (in per cent; Figs. 5, 6 and 7) showed a (vague) linear relationship with a regression coefficient of 0.85. The total pigment standing crop (C ug/1) was related with fluorometry (F percent) in approximately C = 0.01F - 0.1 during this leg.

The concentration of chlorophyll in the surface 10 m was 0.10 to 0.15 ug/l at the 34°N station on March 29, 1989 (Table 7). There was a prominent chlorophyll maximum below 15 m and the concentration reached to approximately 0.35 ug/l at 20 to 50 m below the surface (Fig. 5) representing the highest chlorophyll values among the 3 stations. Chlorophyll *a* dropped to almost zero at 120 m and was not detected by our methods below 200 m.

At the 47°N station, the pigment concentration was the lowest among the three stations we visited and more uniformly distributed throughout the upper 200 m layer. The maximum concentration was found at 20 m where chlorophyll *a* was 0.09 ug/l and total pigments 0.17 ug/1 by analysis (Table 7). The fluorometry profile indicated that there was a layer of pigment concentration at 200 m below the surface with a concentration of about 0.2 ug/l. The pigment concentration rapidly decreased to zero immediately below the mixed layer (Fig. 6).

There were two layers with a higher pigment concentration at the 60°N station. The surface to 40 m layer contained 0.17 ug/l of pigment (Table 7), while the second layer was found below 60 m and was also about 40 m thick (Fig. 7). The pigment concentration in this layer was slightly larger than that in the surface layer: up to 22 ug/g. The pigment standing crop decreased to almost zero at 120 m but there was a very thin layer with relatively high concentrations at 195 m, then completely ceased at 360 m. The fluorometry profile closely resembled the sigma-T curve in the upper layers.

Relative amounts of chlorophyll *a* and phaeopigment represented a state of preservation of phytoplankton pigments. The chlorophyll *a* / phaeopigments ratio at stations 34°N and 47°N was about 1. Below the mixed layer the ratio dropped to <.6, indicating the degradation of chlorophyll *a* to phaeopigment with increasing depth. At 60°N the ratio was 2 from the surface to 50 m , perhaps indicating a fresher crop of phytoplankton.

Figure 5

March 29, 1989
GOFS, LEG 1

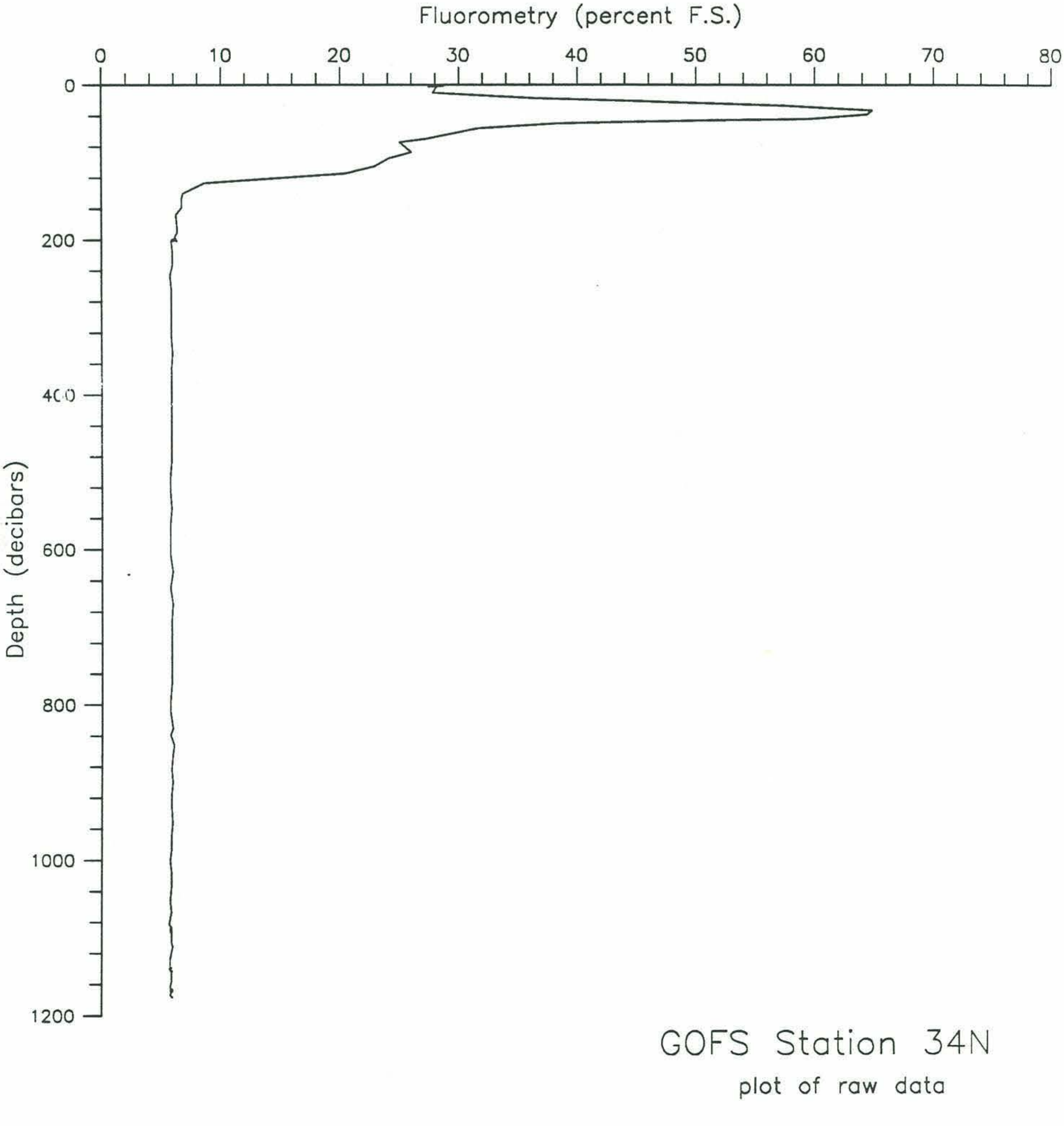


Figure 6

April 3, 1989
GOFS Leg 1

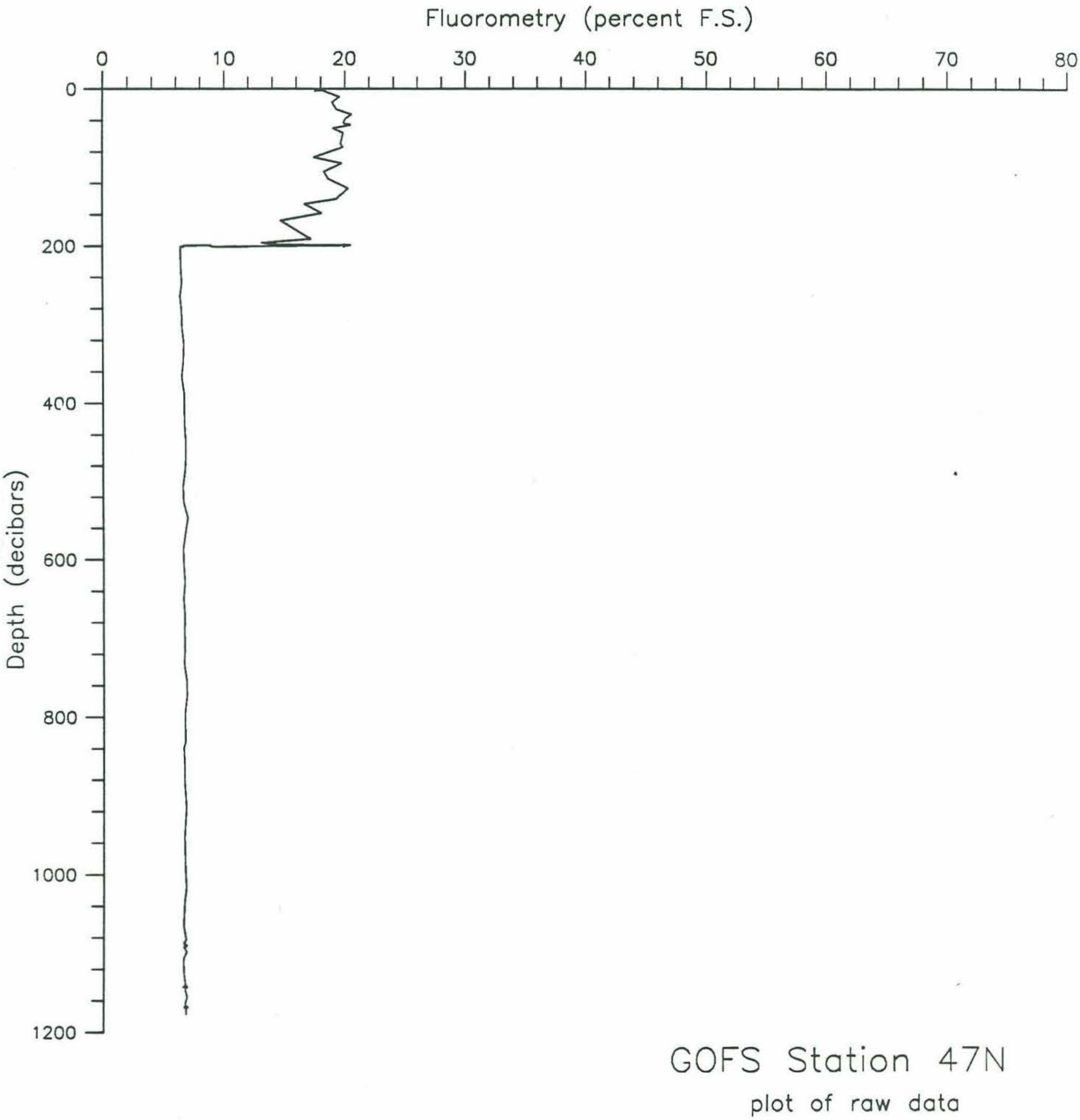
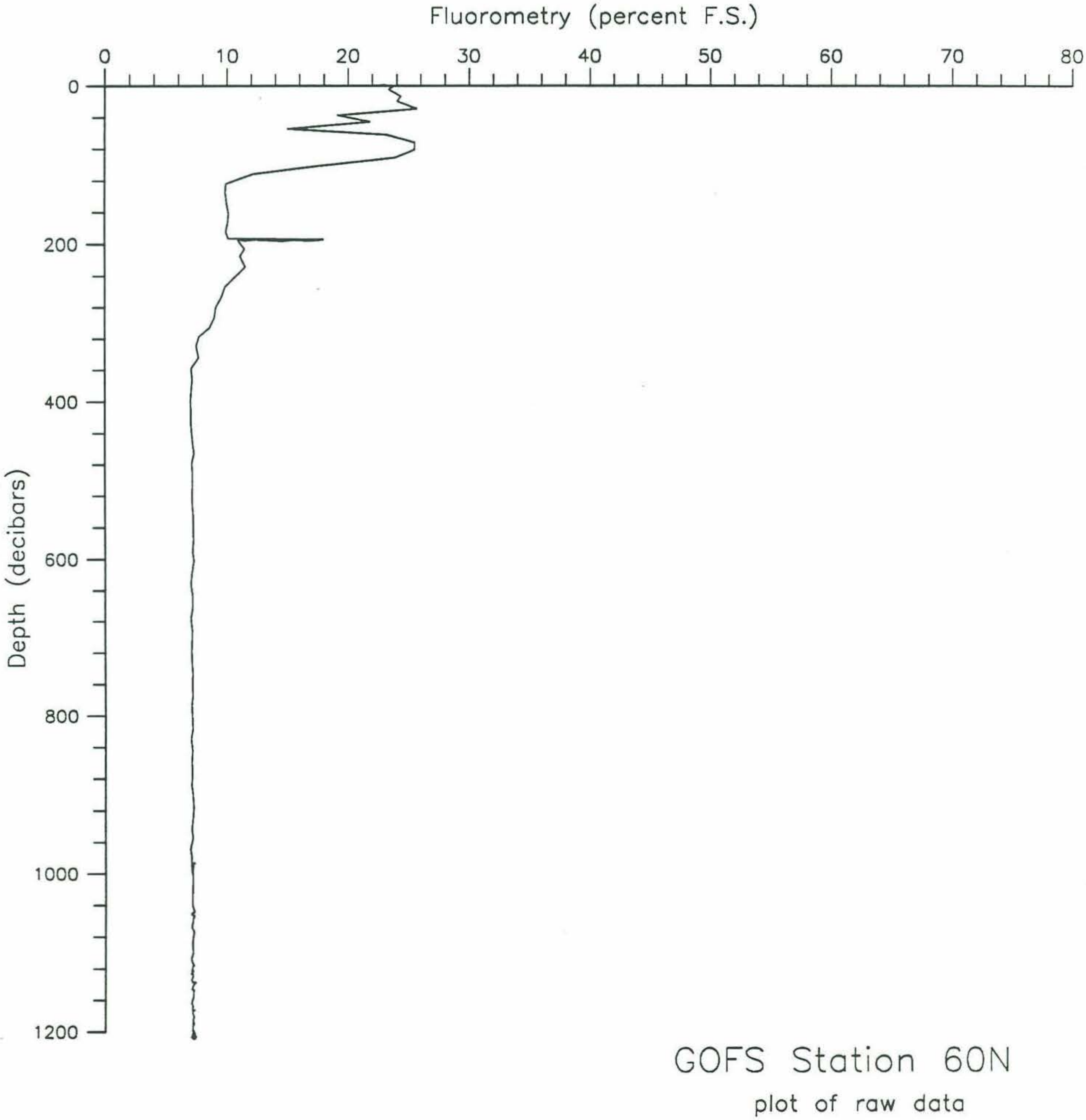


Figure 7

April 6, 1989
GOFS, Leg 1



3.3 Suspended particles and transmissometry

Suspended particles were collected on pre-weighed, 3.5 cm diameter Nucleopore filters with a (nominal) pore size of 0.45µm. We filtered about 10 liters of water onboard immediately after casting. Filters with residual sample were rinsed and air-dried for storage. Later in the laboratory the filtered samples were dessicated for 48 hours and re-weighed. Standard filters without suspended particles were used as the precision reference.

The dry suspended particle standing crop in the upper 100 m at the 60°N, 47°N, and 34°N stations were 28.5 ug/l (s=4.8), 34.5 ug/l (s=4.8), and 120.4 ug/l (s=36.5), respectively (n=5 at each station from 1 to 100 mbs). Suspended particle concentrations were positively related with the pigment standing crop in the upper layers and the majority of suspended particles were planktonic hard tissue, such as (diatomacious) frustules. The approximate relation was:
Susp. particle conc. (ug/l) = 148 x (total pigment stand crop, ug/l) + 12.4 (R=0.93).
Plankton species analyses in the upper water column will not be included in this cruise report.

The standing crop of suspended particles at the 1,000 m level also follows the same trend; it was15.5 ug/l, 27.4 ug/l, and 57.1 ug/l at the 60°N, 47°N, and 34°N stations, respectively (Table 7; Fig. 11, low right). However, as far as we observed at the 34°N station, the suspended particle concentration does not seem to be homogeneous below 400 m, ranging from 21.2 to 57.1ug/l. Therefore, the ranking may not be universally applied. At least the concentration of suspended particles in deep layers at the 60°N station was significantly lower than at the other stations. The differences in content and origin of suspended particles at each station will be reported elsewhere.

We deployed a SEA-TECH transmissometer with a 25 cm optical path and a WHOI 12-bit A/D converter at the 34°N station during one deployment, from the surface to 15 mab (Fig. 8), and one to 4,100 m about 5 hours prior to the first deployment. The surface 10 m was relatively more transparent and there were strong transmission minimums between approximately 10 m to 100 m, followed by the water becoming rapidly transparent between 100 m to 280 mbs. The transmission stayed around 91.2 percent F.S. through 280 mbs to the 15 mab (Fig. 8). No nepheloid layer was found at the 34°N station (transmissometry within 15 m from the bottom is not known).

The relationship between transmissometry (percent F.S.) and (dry) suspended particle concentrations at the 34°N station were found to be not straightforward (Table 8).

Figure 8

Transmissometer Profile a
March 29, 1989
GOFS Leg 1

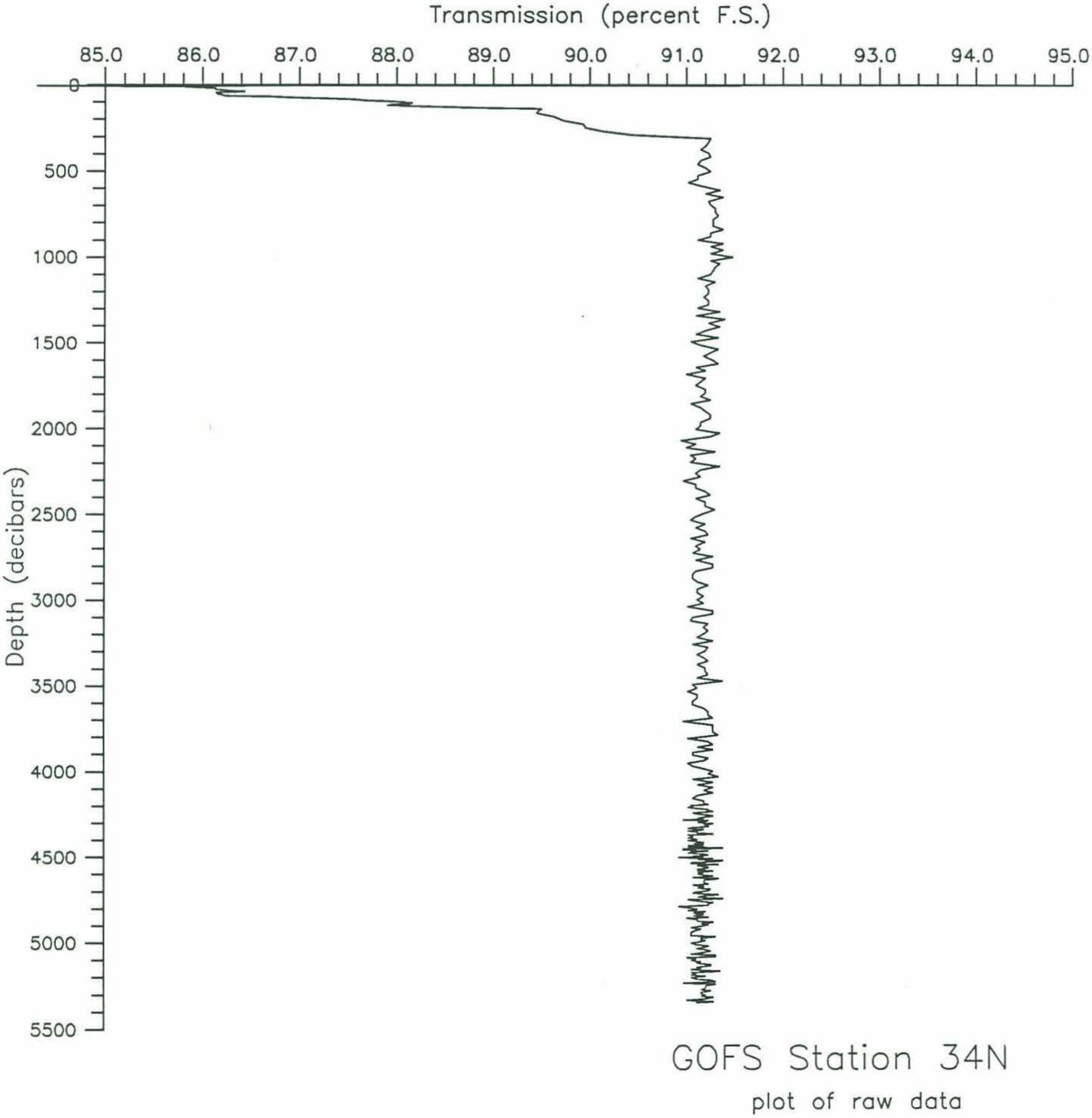


Table 8.

	Surface	10-100 mbs	400-5,185 mbs
Suspended particles ug/l (average)	183 n=1	104 (s:11) n=5	34 (s:14) n=5
Transmissometry (%F.S.) (average)	86.3	84.3	91.2

The material suspended between 10 m to 100 m seems to give significantly less transmission than the material distributed in the very surface layer. At this writing, without examining the plankton samples from each layer, we have no comment for the cause. A relatively wide variation of transmission values in the layer deeper than 400 m, ranging ± 0.4% of transmission, may explain the relatively large variability of suspended particle concentrations, 57 to 21 ug/l (s:14).

3.4 Nutrient Distribution

The average concentration in µmole/liter of NO_3, PO_4, and SiO_2 in the surface to 100 m of water at the 3 stations are compared as follows (Table 9):

Table 9

	NO_3	PO_4	SiO_2
60°N	14.9 (0.3)	0.89 (0.02)	6.6 (0.3)
47°N	9.4 (0.1)	0.58 (0.04)	2.8 (0.1)
34°N	0.4 (0.2)	0.05 (0.03)	0.26 (0.13)

The concentration of all nutrients increased from south to north along the 20°W transect. At the 34°N station, where fluorometry readings were up to 3 times greater than at the other 2 stations, nutrient values were an order of magnitude less than at those same stations (Table 7; Figs. 9, 10). These values: 0.5µg/l NO_3, 0.05 PO_4, and 0.26 SiO_2, possibly indicate a waning of spring bloom conditions. At 47°N nutrients were relatively abundant at 9.4

NO_3, 0.58 PO_4, and 2.8 SiO_2 indicating typical North Atlantic spring bloom conditions.

The highest nutrient concentrations were reported at Station 60°N with 14.9 NO_3, .89 PO_4, and 6.6 SiO_2 (Table 7; Figs. 9, 10) indicating bloom conditions. The concentrations of NO_3, PO_4, and SiO_2 at the 47°N and 60°N stations in the ocean interior (1,000 m deep) were about the same and significantly lower at the 34°N station (Fig. 11).

4. Acknowledgments

We are grateful to Master Richard Bowen and all members of the R/V Atlantis II, Woods Hole, particularly to Bosun Wayne A. Bailey and the deck crew for their high quality assistance during deployments which were done in rough seas and even at midnight. We also thank Leonard Boutin for his assistance as a marine technician. Emily Evans took care of the communications flow from the ship to JGOFS colleagues.

We also thank Dr. Jon Olafsson, Marine Research Institute, Reykjavik, Iceland, for his extensive scientific and logistic advise. He also volunteered to help our scientific party entering and disembarking from Iceland.

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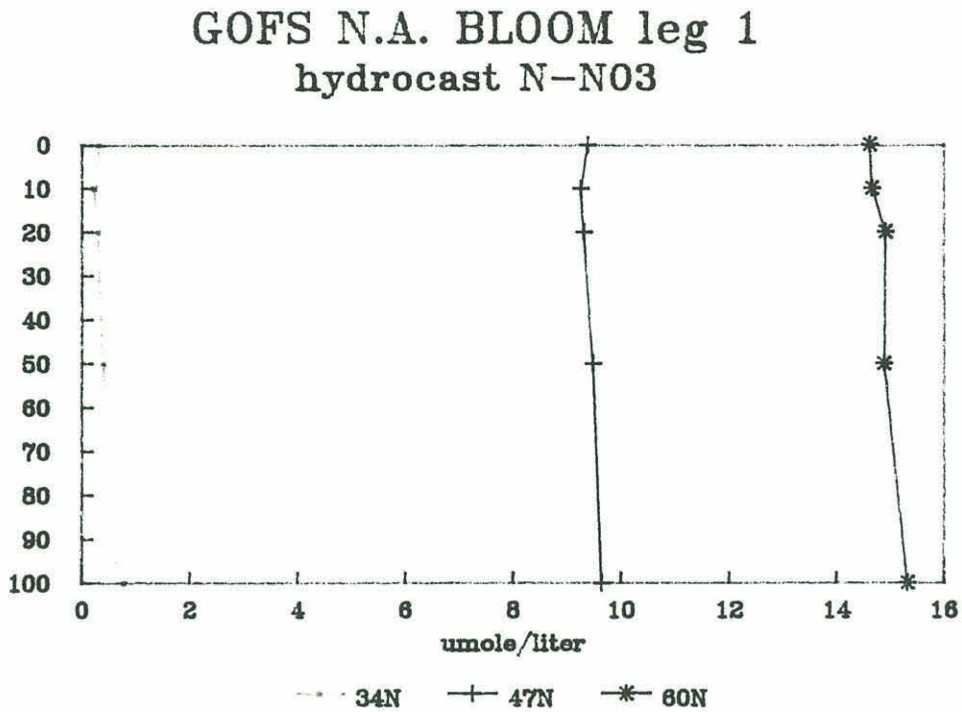
Note: The Navigation, Loran, Satellite, and Echo Sounding Recorder Log, and the position plot charts of the R/V Atlantis II, Voyage 119.2 are archived at the Port Office, Woods Hole Oceanographic Institution, Woods Hole, MA 02543.

Figure 9

March/April, 1989



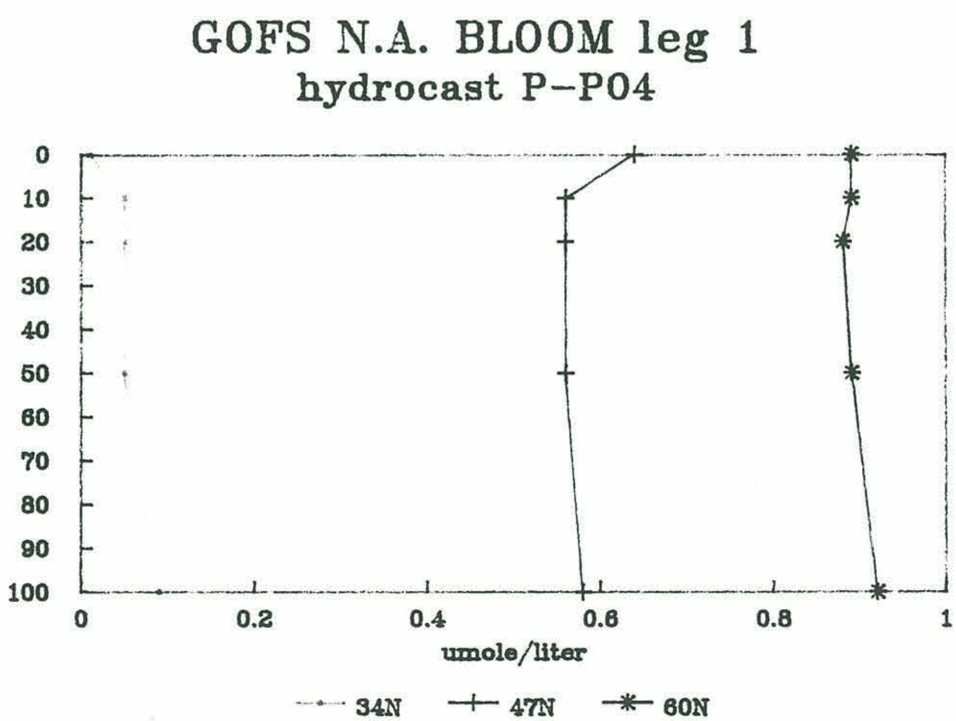
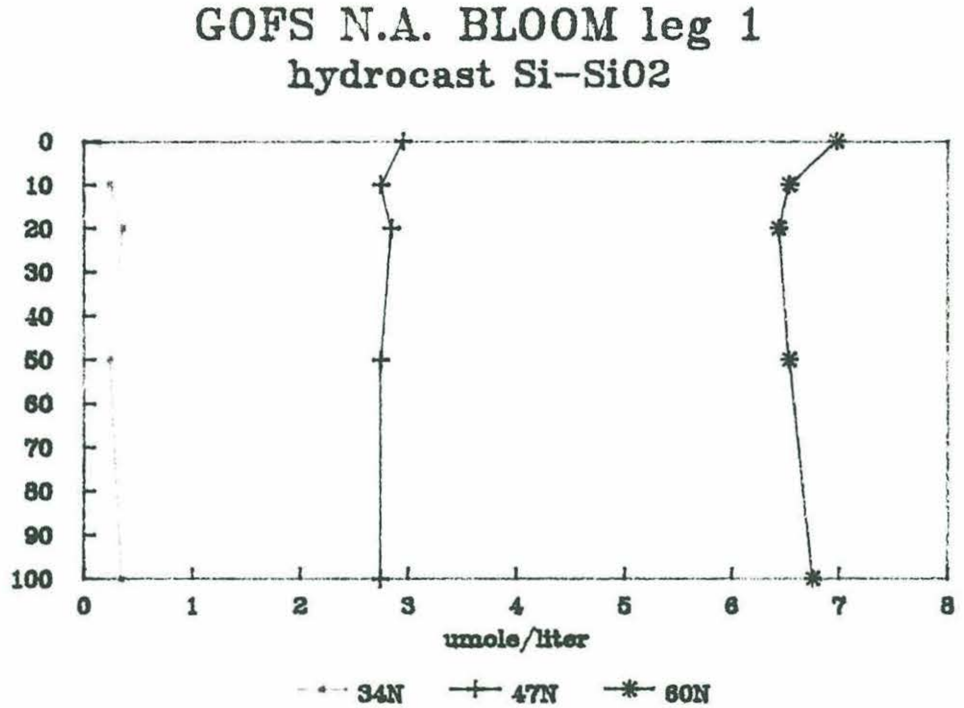


Figure 10

March/April, 1989



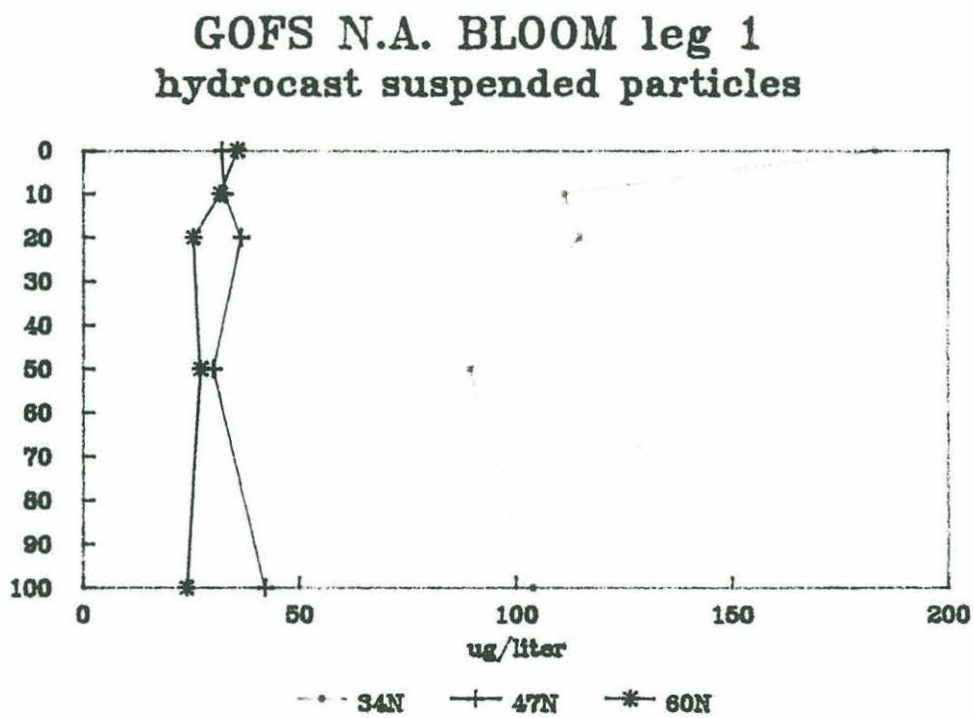
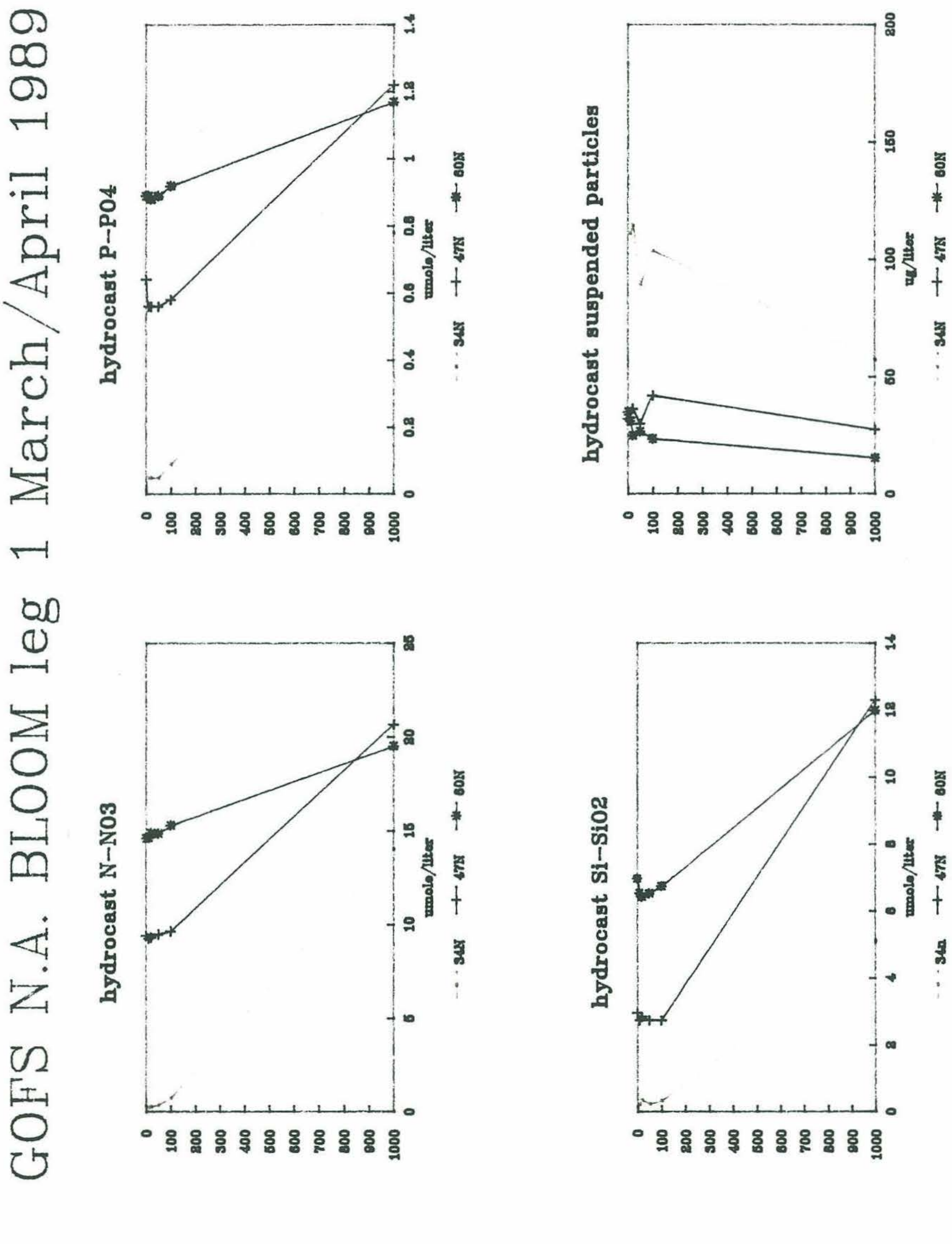


Figure 11



GOFS N.A. BLOOM leg 1 March/April 1989
hydrocast P-PO4
umole/liter
34N 47N 60N
hydrocast suspended particles
ug/liter
34N 47N 60N
hydrocast N-NO3
umole/liter
34N 47N 60N
hydrocast Si-SiO2
umole/liter
34n 47N 60N

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16. Abstract (Limit: 200 words)

With the support of the National Science Foundation, we have completed the first cruise devoted to the GOFS and JGOFS program for the North Atlantic Bloom studies between March 28 and April 6 on board R/V *Atlantis II*. The major task of this cruise, to deploy bottom-tethered mooring arrays with time-series sediment traps along with curent meters at two critical stations, 34°N and 47°N along 20°W, was accomplished. All 6 sediment traps, 3 on each array, were set at 14-day intervals for 13 periods from April 3 to September 26, 1989. Their opening and closing times were synchronized throughout the period of deployment. The arrays and instruments will be recovered and redeployed in September/October, 1989. Ancillary water column data, such as CTD, fluorometry, pigments, and major nutrient distribution, were also successfully completed (except for transmissometry profiling at the 47°N station) in order to understand the pre-bloom setting at JGOFS 34°N, 47°N, and 60°N stations. At the 47°N station on April 2, the mixed layer depth was 248 m.

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2. Sediment trap
3. 20° W bloom study

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